DECELERATION PERFORMANCE COMPARISON FOR PASSENGER CAR UNDER ON-ROAD AND OFF-ROAD DRIVING CONDITION.

MOHD KHAIRIL ASRI BIN KAMALUDDIN

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FACULTY OF MECHANICAL ENGINEERING

I certify that the project entitled "Deceleration Performance Comparison for Passenger Car under On-road and Off-road Driving Condition" is written by Mohd Khairil Asri Bin Kamaluddin. I have examined the final copy of this project and in my opinion; it is fully adequate in terms of scope and quality for the award of the degree of Bachelor of Engineering. I herewith recommend that it be accepted in partial fulfilment of the requirements for the degree of Bachelor of Mechanical Engineering with Automotive Engineering.

(MS. NOR IMRAH YUSOFF)
Examiner Signature

SUPERVISOR'S DECLARATION

We hereby declare that we have checked this project and in our opinion this project is satisfactory in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Automotive Engineering.

Signature:	……
Name of Supervisor:	PROF. DR. HJ. ROSLI BIN ABU BAKAR
Position:	DEAN OF FACULTY OF MECHANICAL ENGINEERING
Date:	6 DECEMBER 2010

Signature:	……
Name of Co-supervisor:	MR. GAN LEONG MING
Position:	LECTURER OF FACULTY OF MECHANICAL ENGINEERING
Date:	6 DECEMBER 2010

STUDENT'S DECLARATION

I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged. The thesis has not been accepted for any degree and is not concurrently submitted for award for other degree.

Signature : ……..
Name : MOHD KHAIRIL ASRI BIN KAMALUDDIN
ID Number : MH 07058
Date : 6 DECEMBER 2010

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ABSTRACT

In deceleration, there are many factors that influent the deceleration performance. The factors are like brake system and the road condition. Other than that, how the driver pressed the brake pedal also influenced the deceleration performance and also the safety during braking. This must be considered during designed the brake system of the car. The objectives of this project are to collect the data of the passenger car during decelerates using the UMP's test car under on-road and off-road driving condition and to analyze the deceleration performance of passenger car for difference deceleration test. This report describes the few type of deceleration by run the test. The test was divided into two sections which are on road and off road. For the on road test, the initial speed of the car before decelerate was varies and control the stopping distance. Base on the theory, the higher the initial speed of the car, the longest time and distance needed to stop safely but for this test, the stopping distance is constant so that the stopping time will decrease if the initial speed is increase. Other than that, the brake system also needs to absorb greater energy and power if the car decelerates from the high speed. For the off road test, the stopping time and stopping distance want to be study base on the initial speed of the car. Finally, some calculations need to be performed using related formulas and equations to know the difference between all the decelerations types. Some graphs was plotted to show the trends and pattern of the result. The results concluded that the braking techniques and ways to reduce the car speed will affect the stopping time, stopping distance, and power and energy absorb by the brake system. Therefore, the road condition also is the main factor that influent the deceleration performance of the passenger car. The results indicate difference deceleration behavior for passenger car under various speed in on-road and off-road condition, which is an important study to develop difference braking techniques.

ABSTRAK

Dalam nyahpecutan, terdapat banyak factor yang mempengaruhi prestasi nyahpecutan. Antara faktor yang mempengaruhi prestasi nyahpecutan adalah sistem brek dan juga bergantung kepada keadaan jalan. Selain itu, cara pemandu menekan pedal brek juga boleh menjadi salah satu faktor yang mempengaruhi prestasi nyahpecutan dan juga keselamatan ketika nyahpecutan. Ini adalah perkara penting yang harus dipertimbangkan apabila mahu mereka sistem brek kereta. Objektif kajian ini adalah untuk mendapatkan data nyahpecutan kereta penumpang menggunakan kereta uji milik UMP di jalan berturap dan jalan tidak berturap dan untuk menganalisa data prestasi nyahpecutan kereta penumpang bagi setiap kes nyahpecutan yang berbeza. Kajian ini menerangkan beberapa jenis nyahpecutan melalui ujikaji. Ujikaji dibahagi kepada dua bahagian iaitu di jalan berturap dan jalan tidak berturap. Bagi ujikaji di jalan berturap, halaju awal kereta sebelum nyahpecutan dibezakan dan jarak untuk kereta berhenti dimalarkan. Berdasarkan teori, kereta yang bergerak dengan kelajuan yang tinggi memerlukan lebih banyak masa dan jarak untuk berhenti dengan selamat tetapi dalam ujikaji ini, jarak kereta berhenti dimalarkan menyebabkan masa nyahpecutan akan berkurang dengan peningkatan halaju awal kereta. Selain itu, sistem brek juga perlu menyerap tenaga dan kuasa yang lebih besar jika kereta mengalami nyahpecutan daripada kelajuan yang tinggi. Untuk ujikaji di jalan tidak berturap, masa nyahpecutan dan jarak kereta berhenti hendak dikaji berdasarkan perbezaan halaju awal kereta. Akhirnya, beberapa pengiraan perlu dilakukan menggunakan formula dan persamaan yang berkaitan untuk mengetahui perbezaan diantara setiap jenis nyahpecutan. Beberapa graf diplotkan untuk menunjukkan corak dan keadaan hasil kajian. Hasil kajian merumuskan teknik membrek dan cara untuk mengurangkan kelajuan kereta akan mempengaruhi masa kereta berhenti, jarak kereta berhenti, dan kuasa dan tenaga yang diserap oleh sistem brek. Walaubagaimanapun, keadaan jalan juga merupakan factor utama yang mempengaruhi prestasi nyahpecutan bagi kereta penumpang. Hasil kajian ini menunjukkan perbezaan keadaan nyahpecutan untuk kereta penumpang pada halaju yang berbeza di jalan berturap dan tidak berturap merupakan satu kajian yang penting untuk menghasilkan perbezaan kaedah nyahpecutan.

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LIST OF SYMBOLS

mm	Milimeter
m	Meter
sec	Second
kg	Kilogram
rpm	Revolution per minute
M	Mass of vehicle
M_s	The torques acting on the wheel calculated from the center of the wheel
F_b	Total brake force of front and rear wheels
F_t	The force acting on the wheel (actually the tire) from the ground as it slides
F_{xt}	Total of all longitudinal deceleration force on the vehicle
F_{br}	The force acting on the brake disc from the brake pad in the caliper
F_{xf}	Front axle braking force
F_{xr}	Rear axle braking force
r_w	The radius of the wheel inclusive tire
r_{br}	The radius of the brake disc
V	Forward velocity
V_f	Final velocity
V_o	Initial velocity
D_A	Aerodynamic drag
D_x	Linear acceleration
a	Acceleration rate

$-a_x$	Linear deceleration
d	Distance traversed during acceleration (braking distance)
e	Perpendicular distance from actuation force to pivot
N_A	Normal force between lining A and drum
N	Perpendicular distance from lining friction force to pivot
m	Perpendicular distance from the normal force to the pivot
W	Vehicle weight
g	Gravitational acceleration
Θ	Uphill grade
t_s	Time for the velocity change
C	Aerodynamic drag factor

LIST OF ABBREVIATIONS

M/T	Manual transmission
USB	Universal Serial Bus
ABS	Antilock brake system
F1	Formula One
SD	Stopping Distance
DAS	Data acquisition system

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Acceleration and deceleration are two terms that have quick similar meaning but have a few different in term of sign of it magnitude. Many car manufacturers were produces car with high performance during speeding or acceleration without think about the deceleration performance. Actually, many accidents happen because of the car or driver cannot brake or slow down the car in the correct time. The deceleration technique is more important compare to the acceleration technique. Many people know the acceleration technique but less skill in deceleration technique. The wrong braking and deceleration technique will effect to the car structure and also can make the car loss control and accident. Besides that, the correct deceleration technique will increase the lifetime of the tires and will affect the fuel consumption.

The brake is the system that functions as a tool to stop the car or make the car decelerate. But many people do not know how to use the brake correctly, that is will give less impact to the car structure and protect from accident. In this report, the mechanism when the brake pedal was press is analyzed and the value of stopping time, stopping distance and energy and power absorb by the brake system will be determined.

1.2 PROBLEM STATEMENT

Increasing the numbers of accident happens become one of the biggest challenge and the important thing that must be thinking by engineers or designer in automotive sector (Georg, 2009). The effect that influent this matter happen must be counter and minimize. Many of accident happen because of the brake of car malfunction or the brake system cannot stop the car in the short time (Mustafa, 2005). In the other words, many accidents happen because the car cannot decelerate correctly. Also, unstable condition of the car when the car was suddenly braked will cause the car unbalance and accidents happen.

Besides, many car manufacturers not focus and highlight about the deceleration performance like they are encourage about the acceleration performance. It can be seen on the broacher of the car, they clearly show the acceleration performance of the car without stated any info or details about the deceleration performance (Georg, 2009).

Other than that, the important thing with the brake system is the ability of the brake system to stop the car in the short distance without slip. When the car or vehicle move with high speed, it will take more time to stop safely because of the car's momentum and inertia principle. The brake system functions as a component that make the car decelerate or facing the decreasing of velocity. The deceleration also can happen naturally, without the force from brake. The deceleration of the car will happen under various conditions. The technique of braking is important for difference speed and road condition. It is important to know the relation between braking skill or technique with the distance and time to the car stop.

1.3 OBJECTIVES

The objectives of this project are:

i) To collect the performance data of the passenger car during decelerates using the UMP's test car under various type of deceleration.

ii) To analyze the deceleration performance data for passenger car.

1.4 PROJECT SCOPES

The scopes of this project are:

i) Literature review of relevant and related information about this study.

ii) Test car system installation like sensors involve and data storage system.

iii) Experiment setup of the testing design, road and method selection.

iv) Data collection by run the testing to get the data for analyzes.

v) Deceleration performance analysis to reach the aim or objective of this study.

vi) Final report preparation.

1.5 HYPOTHESIS

In deceleration, when the stopping distance is constant, the car moving with high speed will have shortest stopping time, greater energy and power absorb by the brake system and also high vibration impact compare to the car moving with low speed.

1.6 PROJECT FLOW CHART

In order to achieve the aim and the objective of the project, a methodology was constructed to have a proper guidance for a successful experimentation. The flow chart for the project is as follow:

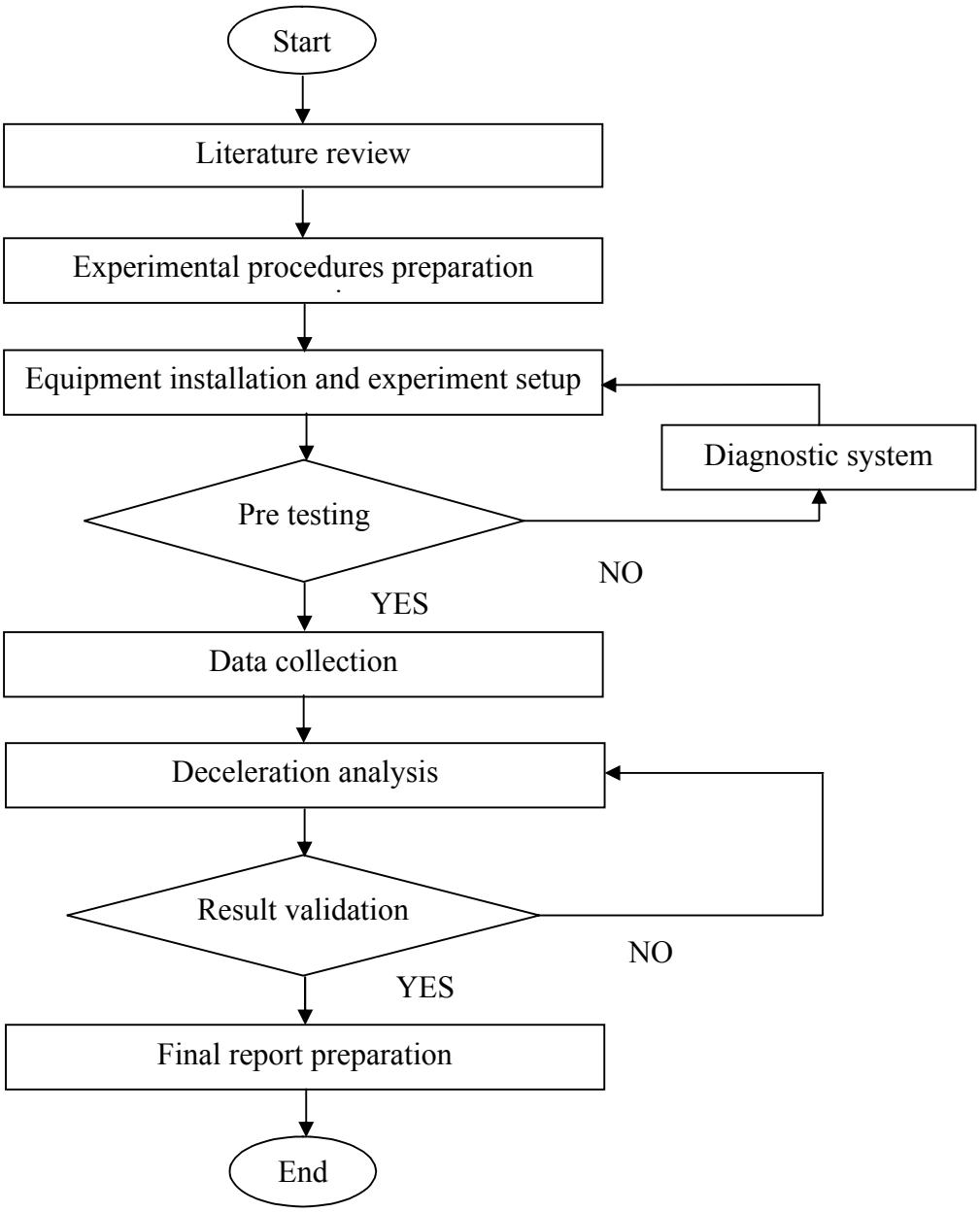

Figure 1.1: Flow chart of the project

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The process of braking is important in automotive performance, which impacts the safety of traffic. Several parameters of braking can be determined on stationary test stands, however, more accurate data that can be used in a more simple way in practise are gained by doing tests on the road. One of the causes of traffic accidents is the technical condition of automobiles. The key characteristic of an automobile's technical condition, which impacts the safety of traffic, is the brake system and the effectiveness of its performance which the period and the distance needed to stop an automobile depend on. One of the ways to reduce a number of traffic accidents is to improve the methods and ways of controlling the parameters of braking or decelerating for automobiles. The effectiveness of parameters of braking does not mostly depend on the age of automobiles, but on the technical condition of the brake system of the automobiles (Dainis, 2009).

The braking system constitutes an integral part of an automobile. Failure of the automobile brake system at the time of emergency can lead to accidents, property damage or even death of an individual (Newcomb and Spurr, 1967). In recent years, braking systems have undergone tremendous changes in terms of performance, technology, design and safety (Dainis, 2009). Today, the brake engineer has two challenges (DaimlerChrysler, 2002):

i) Create enough deceleration to stop the car as quickly as the driver wishes, without exceeding the drivers comfort level with regard to pedal effort or pedal travel.
ii) Manage the resulting heat energy so as not to damage the brake system or the rest of the vehicle.

Anti lock brake systems are the most sought after these days, which are now used in almost all the vehicles. A review of the literature was performed to identify studies relevant to the topic.

2.2 PASSENGER CAR BRAKE SYSTEM

The brake system is one of the important aspects that can influent the deceleration performance of a vehicle. The braking system constitutes an integral part of an automobile. Besides that, failure of the automobile brake system at the time of emergency can lead to accidents, property damage or even death of an individual (Heinz, 2002). The passenger car can be characterize as all sedans car, coupes, and station wagons manufactured primarily for the purpose of carrying passengers or passenger cars pulling recreational or other light trailers. It can divide into a few types like below (Carlos, 2005):

i) Mini (PC/Mi) (680-899 kg curb weight)
ii) Light (PC/L) (900-1129 kg curb weight)
iii) Compact (PC/C) (1130-1359 kg curb weight)
iv) Medium (PC/Me) (1360-1599 kg curb weight)
v) Heavy (PC/H) (1600 kg and over. Curb weight.)
vi) Sport utility vehicles (SUV)
vii) Pickup trucks (PU)
viii) Vans (VAN)

Braking system comprises from several parts such as brake pads, brake booster, brake discs, brake calipers, brake cylinders, brake drums, brake wires, wheel studs, clutches, valves, brake hoses, vacuum pumps, brake rotors, sprockets, brake